# Stabilizing Red Fluoride Phosphors for White LEDs using Atomic Layer Deposition

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Recently, red fluoride phosphors such as $K_2SiF_6:Mn^{4+}$ [1-2] gained a lot of attention as the red component of white light-emitting diodes (wLEDs). As the $[MnF_6]^{2-}$ complexes show a narrow luminescence band centered at around 630 nm upon blue LED excitation, they possess distinct advantages over the frequently used $Eu^{2+}$-based nitride phosphors. The latter suffer from reabsorption issues if used in a phosphor blend. Moreover, the attainable luminous efficacy of wLEDs using red $Eu^{2+}$-doped nitrides is limited since a considerable fraction of the nitride emission extends above 650 nm, a spectral region in which the human eye sensitivity is low.

Despite the excellent optical properties of many fluoride phosphors, a remaining hurdle is the moisture sensitivity of these materials. Hence, surface passivation of fluoride phosphors has been an important topic in recent literature[3-8]. Conventional passivation methods are based on wet chemical processes, degrading the pristine material. Moreover, in heterogeneous core-shell approaches, the fluorine terminated surface of the core shows a lack of functional sites (e.g. hydroxyl groups) inhibiting efficient bonding with typical shell materials.

In this work, the use of atomic layer deposition (ALD) for growth of $Al_2O_3$ and $TiO_2$ seed layers on fluoride phosphor particles is investigated. The coated phosphors have hydroxyl-saturated surfaces that are compatible for further bonding with hydrophobic shells. It was found that $Al_2O_3$ seed layers suffer from blistering, pore-formation and delamination. In contrast, conformal and uniform layers of $TiO_2$ could be grown. Unlike the untreated phosphor, the $TiO_2$ coated phosphor could easily be further treated with a hydrophobic shell.

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